PRESSURES ON OSTEOLOGICAL COLLECTIONS - THE IMPORTANCE OF DAMAGE LIMITATION

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Abstract

Physical anthropology has been taught in the Department of Archaeological Sciences at the University of Bradford at both undergraduate and postgraduates levels since the late 1970s. This study assesses the impact of use on the archaeologically derived skeletal collections curated by the Department. A recent survey of a sample of adult skeletons from two different archaeological sites, and the evidence of damage to those skeletons in the form of bone element loss, postmortem fractures and surface erosion over a number of years of use is reported. The results showed that the heavy use skeletons suffered most damage and loss, and hands, feet and teeth were lost most. Repaired and failed repair breaks also occurred, particularly in the heavy use group. Much of the element gain was attributed to poor initial recording. Packaging was also poor in general. This study has resulted in a re-appraisal of handling and packaging procedures.

Introduction

'It is generally accepted that the quality of the information that can be gained from archaeological remains is inversely proportional to the degree of degradation during burial. It is often forgotten, though, that the value of these remains is also affected by the way in which they have been treated since the moment of discovery... Just as harmful can be the hidden damage (caused) by poor packaging, bad handling practices and low grade storage' (Spriggs, 1989: 39)

Physical/biological anthropology has been taught in the Department of Archaeological Sciences at the University of Bradford at both undergraduate and postgraduates levels since the late 1970s. Initially classes were devoted mainly to the teaching of palaeopathology, reflecting the interests of Dr. Keith Manchester who instigated teaching in this area. However, a wider range of subjects is now taught, including modules in basic osteology, human evolution, forensic anthropology and palaeopathology. These courses form part of the following degrees: BSc Archaeology, BSc Archaeological Sciences, BSc Bioarchaeology, MA Scientific Methods in Archaeology, MSc in Osteology, Palaeopathology and Funerary Archaeology, and MSc in Forensic Anthropology. The teaching ethos of the modules utilizes the laboratory as the main vehicle. This allows students to learn about the human skeleton and its variation. Skeletal collections have been acquired to fulfill this need (especially over the last ten years) to accommodate the increase in student numbers. This paper, therefore, aims to assess the impact of the pressures of use mainly by students on the archaeologically derived skeletal collections curated by the Department of Archaeological Sciences at the University of Bradford, England. More specifically, the first half of the paper traces the development of physical anthropology teaching in its widest sense in the U.K. and at Bradford, the history, and increasing importance, of the curation of our skeletal collections, and the types of use to which skeletal material is put. The second half of the paper focuses on a recent survey of a selected sample of skeletons from two different archaeological sites curated at Bradford, and the evidence of damage to those skeletons in the form of bone element loss, postmortem fractures and surface erosion over a number of years of use. Reference is also made to storage conditions and standards of packaging skeletal material. The paper finally discusses limitations of the study and some recommendations, with reference to other published work, although another paper in this volume covers this latter aspect more fully (Janaway *et al.*). To the authors' knowledge a study such as this has never been carried out to date.

Teaching of Physical Anthropology: The Experience in the U.K.

Unlike North America (A.A.A., 1998), in the U.K. the teaching of physical anthropology in Universities, if it is taught, rests with archaeology departments and also a small group of anthropology departments. There are approximately 30 archaeology departments in the U.K., and within that group there are about ten who do any serious teaching in physical anthropology, mainly at the undergraduate level. Those that teach in the area also curate collections of skeletons for teaching, and courses and modules taught in physical anthropology are usually oversubscribed; for example, at Bradford in the semester running from September 1999 to January 2000), 60 students took an undergraduate module in Human Osteoarchaeology which involves laboratory teaching.

Although physical anthropology is not taught as widely in the U.K. as in North America, when it is, it is extremely popular with students. Recent media coverage of human skeletal analysis from archaeological sites (such as "Meet the ancestors", a BBC program which regularly sees 3-4 million viewers) has contributed to an increased interest. Disregarding the media hype there is obviously a need for this teaching that requires careful planning and thought.

Another, perhaps more positive, difference between teaching physical anthropology in North America and the U.K. is that in the U.K. most practically based teaching is undertaken using skeletons from archaeological sites. This may be because there has not been the pressure of repatriation and/or reburial (Rose *et al.* 1996), and thus skeletal collections have been easily available. The public at large, and archaeologists more specifically, are becoming much more aware of the implications of this issue in the U.K (Parker Pearson 1995). However, a recent study (Orgill 1999) suggests that the British public do not appear to be as concerned as implied in some of the archaeological literature. Guidelines for the treatment of human remains in archaeological contexts have also been drawn up in Ireland (Buckley *et al.* 1999) and Scotland (Historic Scotland 1997) emphasizing the ethical considerations. In addition, publications have also

appeared regarding burial archaeology and the law in England, Wales and Scotland (Garrett-Frost, 1992) and the excavation of human remains and their treatment (McKinley & Roberts 1993). While the use of anatomical replicas in the form of plastic models of appropriate bones and whole skeletons may be pertinent for basic anatomy classes, experience at Bradford suggests that most plastic replicas on the market do not show the detailed anatomical features of the skeleton, and do not illustrate the larger variation (from obvious to very subtle) that exists within and between populations. It is considered, therefore, that the teaching of physical anthropology and all its sub-disciplines is better served by using archaeologically derived human skeletal material in most cases.

Focus on Bradford: Teaching of Physical Anthropology over the last Ten Years

The teaching of physical anthropology at Bradford started in the late 1970s with the arrival of Keith Manchester (a general practitioner/primary health care physician) as an occasional lecturer in the Department of Archaeological Sciences. At the time, only small groups of students (about 10-12) were taught (mainly paleopathology) in each one of the term's eight weeks for two hours. The students used two skeletal collections acquired by the Department, one through a student who had excavated the site (Raunds, Northamptonshire) and the other through work Manchester had done on a collection from Eccles, in Kent.

In 1983, with the arrival of Charlotte Roberts, the number of contracts involving skeletons from archaeological sites increased, as did the skeletal collections in the Department. In the U.K. there has been a tendency for the archaeological organization/unit, which has excavated the skeletal material, to allow curation to be carried out by the institution where the analytical work is carried out. This may be because the archaeological unit has storage restrictions and/or they wish the material to be used for the benefit of others. The material is then used for teaching and research, and usually an agreement is drawn up between the archaeological unit and the University. In 1984, the Calvin Wells Laboratory was established following the donation of the late Calvin Wells' archive by his widow. Calvin Wells was a Norfolk based general practitioner who had an interest in human remains from archaeological sites (especially with respect to palaeopathology) and, to date, his publications far outnumber any other physical anthropologist's in the U.K. (Hart 1983). The Laboratory rapidly became a recognized center for the study of physical anthropology and during the 1980s the numbers of students taught by Keith Manchester increased, but not substantially. Following the appointment of Charlotte Roberts to a lecturer post in 1989 a new Masters course in Osteology, Palaeopathology and Funerary Archaeology was established and run jointly between Bradford and the University of Sheffield.

Although initially a course with seven students, it quickly gained in popularity with a concomitant increase in students (1989-2, 1990-7, 1991-12, 1992-9, 1993-11, 1994-18, 1995-20, 1996-19, 1997-21, 1998-22, and 1999-14). Running parallel with this increase in postgraduate students on the course was an increase in undergraduate numbers from 26 in 1989 to 72 in 1999 (1990-34, 1991-44, 1992-45, 1993-52, 1994-54, 1995-67, 1996-88, 1997-90, 1998-89), reflecting current government policies on higher education. As the overall numbers of students increased, the numbers of undergraduates opting to take the Human Osteoarchaeology module also rose (24 in 1992, 12 in 1993, 12 in 1994, 24 in 1995, 20 in 1996, 26 in 1997, 33 in 1998, and 53 in 1999). In addition, students from the MSc in Forensic Anthropology and the MA in Scientific

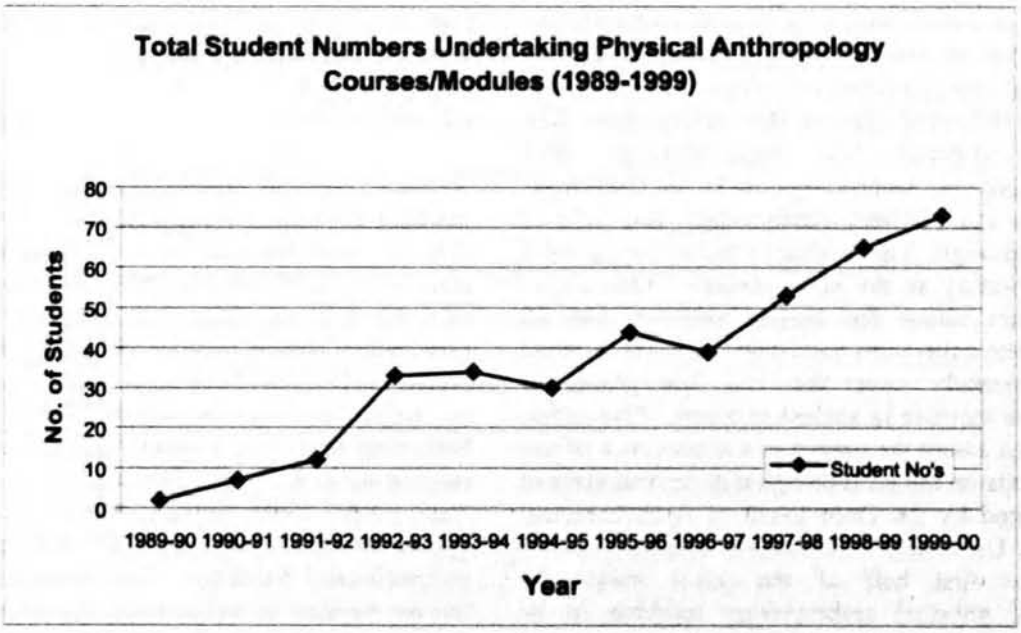

Fig. 1 – Numbers of students in physical anthropology (1989-1999)

Methods in Archaeology can opt to take this module. In 1997 another new masters course (MSc Forensic Anthropology) was started, taking six students in 1997, 10 in 1998 and six for 1999. In 1997, new undergraduate modules in Biological Anthropology also started (numbers last year were 67), and in 1996 a module was created in Forensic Anthropology for students taking the BSc in Chemistry with Pharmaceutical and Forensic Science (numbers were 36 in the 1999-2000 academic year).

Thus, the numbers of hours physical anthropology laboratory classes in a wide range of areas are taught have risen over the years from about 16 to about 200 hours over the 24-week teaching year. The numbers of students taking laboratory based classes in physical anthropology have also risen (fig. 1), and from 1996-7 the numbers have nearly doubled. In addition, short laboratory based professional courses accepting about 30 students were run for one to two weeks in the summers of 1988 (1), 1994 (1), 1996 (1), 1997 (1) and 1998 (2). A number of adult education classes (evening classes, day and weekend schools) have also been organized during the 1980s and 1990s, all with varying amounts of time spent in the laboratory handling skeletal material. Finally, the number of undergraduate and postgraduate students (masters and PhD) utilizing the skeletal collections for their dissertations has also increased over the years. Students are, to a certain extent, allowed unsupervised access to selected "practice" skeletal material to help with their studies. For the last ten years, students in all of the courses have been instructed in the fragile and non-renewable nature of the skeletal material used in the laboratory. Benches are covered with protective material (bubblewrap) to prevent damage, and a diagram illustrating the way to place a skeleton into a box is available. These instructions are also given to any visiting researchers who access the collections (Janaway *et al.* this volume).

Skeletal Collection	Date Acquired
Eccles, Kent	1980
Raunds, Northamptonshire	1982
Baldock, Hertfordshire	1987
Chichester, Sussex	1988
Kingsholm, Gloucestershire	1988
Addingham, West Yorkshire	1990
St. Giles, North Yorkshire	1991
Blackfriars, Gloucester	1992
Chichester, Sussex	1997
Tanners Row, Pontefract	1998
Hickleton, Derbyshire	1999

Table 1 – Skeletal collections in the Department of Archaeological Sciences, University of Bradford.

In order to teach physical anthropology as a laboratory based discipline, the Department has required skeletal collections. The Calvin Wells Laboratory curates around 1500 skeletons of varying age, from a range of geographic areas in the U.K. These skeletons were acquired at various times during the Laboratory's history (Table 1). Additionally, there are some smaller and/or partial sites, as well as skeletons that are temporarily curated for the purposes of analysis. Due to its large size, the collection is currently housed in four different locations, mainly within the Department of Archaeological Sciences. Over the years, the collection has been housed in a number of buildings within the confines of the University, close to the University, and in areas outside of the main city, depending on availability. None of the storage areas has, or had, environmental control. They do not, therefore, meet current Museums and Galleries Commission (MGC) standards, and the environmental conditions have varied from dry to very damp. Inevitably, transport to and from these various locations has affected the collections' condition. Thus, burial environment, excavation techniques, processing, packing, transport, curation and handling have all undoubtedly contributed to the current condition of the material. Furthermore, the collection has never had a full time curator. This deficiency has mainly been because of a lack of funds to support such a position, although the department has been made aware of the need.

Location	Date
21 Claremont (old Archaeological Sciences Department)	1982-1983
Wardley House (temporary Archaeological Sciences Department)	1983-1984
Warehouse at Wrose, Bradford	1984
Salts Mill, Bradford	1985-1986
Blockhouse (Horton A, Current Archaeological Sciences Department)	1986-c.1994?
Richmond Building Basement (main University building)	c.1994-present
Laboratory Storage Area (Horton D, University)	1998-present

Table 2: Storage history for Raunds. Source: Keith Manchester (pers.comm.)

Materials and Methods

The sites used

The two sites used to survey the collection came from cemeteries in Sussex and Northamptonshire. Three hundred and fifty-one skeletons were excavated from the later Medieval (12^{th} –16^{th} cent. AD) lepers' hospital of St. James and St. Mary Magdalene in Chichester, West Sussex between 1986 and 1987 (Magilton & Lee 1989). A further forty-four were excavated in 1993. Since their arrival in the Department of Archaeological Sciences at the University of Bradford, they have been stored in the Department's main store, and in the teaching and research laboratories. The skeletons excavated in 1986-7 have been in the Department for about eleven years and, for the purposes of this study, were named the "Old Chichester" sample. The more recently excavated skeletons have been in the Department for about a year and, for this study, were named the "New Chichester" sample. The other site, Raunds in Northamptonshire, produced three hundred and sixty-three skeletons, which were excavated between 1977 and 1984 (Boddington 1996). Since 1982 material from the site has been stored in at least seven locations (Table 2). The first location, the former Archaeological Sciences

Department in 21 Claremont, was damaged in 1983 by an explosion in an adjacent garage, and part of the collection was lost since it was stored in the basement of this building. Undergraduate dissertations of the period refer to this 'unfortunate explosion' (Cameron 1984: 13; Thompson 1985) and, in fact, part of the work undertaken by Cameron 'involved separating the skeletons into individual bodies and helping to rebox them'. This explosion probably caused the most damage (in the form of fragmentation, and loss and mixing of elements) during the curatorial history of this collection. The bone elements from both sites were marked with Indian ink, although the consistency of elements marked varied. Marking, in theory, should ensure that the right bones stay in their respective boxes or are placed back into the right box.

Selection of samples

Forty adult skeletons were selected from the two sites, most of which have been used extensively for teaching and research over the years. Reconstructing the "use history" of the skeletal material, involved establishing areas and pressures of use including: dissertation/thesis work (undergraduate, masters and PhD), laboratory classes, course assessments (e.g. the skeletal reports by students doing the MSc in Osteology, Palaeopathology and Funerary Archaeology), visiting researchers, summer schools and short courses. The lack of record keeping, and changes to both course and module structure (and to delivery within those courses and modules), make establishing exact use impossible. However, it was believed that the resulting figures would give an idea of the minimum use of the collections, and which skeletons were used most frequently. Of course, this is only based upon known use; it is possible that "less frequently" used skeletons have actually been more frequently used than believed. Thirty skeletons were selected, on this basis, from Chichester (including ten "New Chichester" to represent a "light use"/non-use group, and twenty "Old Chichester" to represent a "heavy use" group). Ten skeletons from Raunds, also representing high and light use groups, were selected. Of the "New Chichester" skeletons selected (Table 3), five had been used for teaching for the first time in 1998-9 while the rest had never been used except by a visiting researcher in July/August 1999. It was apparent that non-adult skeletons from both sites were used far less frequently than adult skeletons. Due to this, and to the differences in size and fragility between adult and non-adult skeletons, it was decided to concentrate on adult skeletons. The "less frequently" used skeletons tended to be less well preserved, possibly the reason why they were not used as often. Although the Chichester skeletons have been in the Department for a shorter time (11 as opposed to 17 years), the skeletons have been used in roughly the same number of undergraduate and postgraduate (Masters) dissertations as the Raunds material. Chichester is also used more frequently for the skeletal report assessment by the MSc students, and by laboratory classes because of the high proportion of pathological examples. For example, 124 Chichester skeletons were used in various classes (37.6% of the total cemetery, and 51.7% of the adults in the group), while only 13.7% (51) of the total Raunds sample was used comprising 26.4% of the total adults for this population. Overall the Chichester material has been used more intensively than the Raunds material.

Old Chichester		**New Chichester**		**Raunds**	
Heavy Use	*Light Use*	*Used Once*	*Unused*	*Heavy Use*	*Light Use*
C40	C8	C337	C345	R5026	R5048
C79	C20	C339	C350	R5150	R5323
C115	C28	C346	C353	R5166	R5364
C128	C71	C348	C357	R5202	
C142	C123	C351	C368	R5207	
C148	C138			R5224	
C158	C144			R5287	
C187	C241				
C272	C305				
C273	C325				
10	**10**	**5**	**5**	**7**	**3**

Table 3 – Skeletons selected for study

Methods used

A standard recording form developed specifically for the study was used (Appendix 1). Particular features were noted.

Loss of elements

Two indicators of damage were recorded by condition scoring: loss of skeletal and dental elements and physical damage to the elements. To assess the loss of elements, the elements present at the time of this study were compared with those present on the original recording form. If an element was present and matched the description given in the original recording form, it was given a score of one. If it was present on the original form but now absent it scored zero. Where only partial elements survived in comparison to the original descriptions these were scored as fractions. The current condition score was subtracted from the original record to assess the number of elements lost. A negative result indicated a loss and a positive result a gain. The original Chichester recording forms give the number of fragments present but, unfortunately, the Raunds forms did not.

The skeletal elements were divided into large elements (e.g. long bones of arms and legs), hand elements and foot elements, plus teeth, in order to assess loss to particular parts of the skeleton. In the case of the vertebrae and ribs, loss assessment proved quite difficult for a number of reasons but space prevents discussion. The proportion of lost elements compared to the total lost elements was also calculated. It was expected that more small elements (such as hands and feet) would be lost than large elements.

Condition of elements

The condition of the elements was compared to the descriptions on the recording form in an attempt to assess the damage sustained. Photographs of some of the elements were also available and were used as a

comparative tool. It was assumed that the photographs were taken soon after the skeletons entered the collection, but this could not be proved, since there were no dates linked to the photographs.

The presence of postmortem damage was recorded for each skeleton. Damage that occurred in the burial environment was differentiated from damage that had occurred since excavation. The following criteria were used to identify damage that occurred in the burial environment:

- staining (i.e. similarity in color between the surface of breaks and the cortical surface),
- angularity (i.e. by the more rounded edges to the break,
- presence of soil in the break surface, and
- presence of soil in exposed trabecular bone.

Repaired breaks and failed repairs, where either an adhesive had failed or the element had been re-broken, were also noted.

Packaging

As part of the study the standard, adequacy, suitability, and types of packaging materials used were also assessed. The order in which elements were packed was examined by dividing the box into layers and scoring elements according to the layer in which they were found. A score of one was applied to elements, which lay on top of others (i.e. those with no elements above), a score of two to elements sandwiched vertically (i.e. those with elements above and below), and a score of three was applied to elements in the base of the box (i.e. those with elements above but no elements below).

Fig 2 – Loss of periosteal (pathological) new bone formation from tibia

Results

Loss of elements

Overall, 72.5% of the forty skeletons assessed had lost elements, or parts of elements or pathological lesions (fig. 2). Of this group 40% had lost large elements (or parts of large elements), 42.5% had lost hand elements, 40% had lost foot elements and 32.5% had lost some teeth (Table 4). When the data was divided into different use groups it became apparent that more of the "heavy use" skeletons had lost elements (94.1%) than the "light use" group (76.9%) or the "New Chichester" group (30%). Similar trends are apparent in the element subgroups (Table 4 and fig. 3).

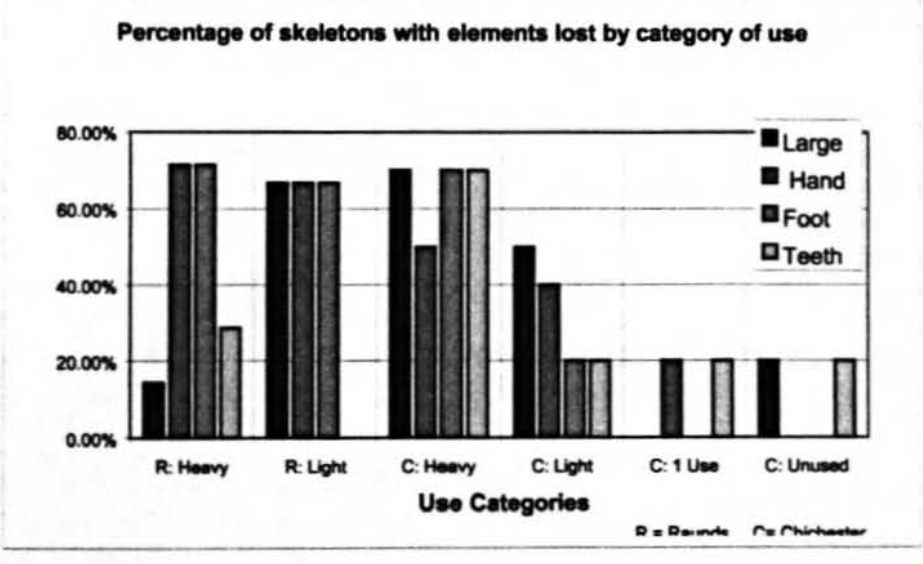

Fig. 3 – Percentage of skeletons with lost elements by use group

Overall, 174.6 elements (4.6%) had been lost from an initial total of 3779 (including teeth). More elements were lost from the "heavy use" group (total 62.1 or 4.1%, excluding teeth) compared to the "light use" group (49.0 or 6.5%) or "New Chichester" (21.5 or 2.5%) – Table 5 and Fig. 4. The latter score was skewed by the loss of 21 elements from skeleton C348.

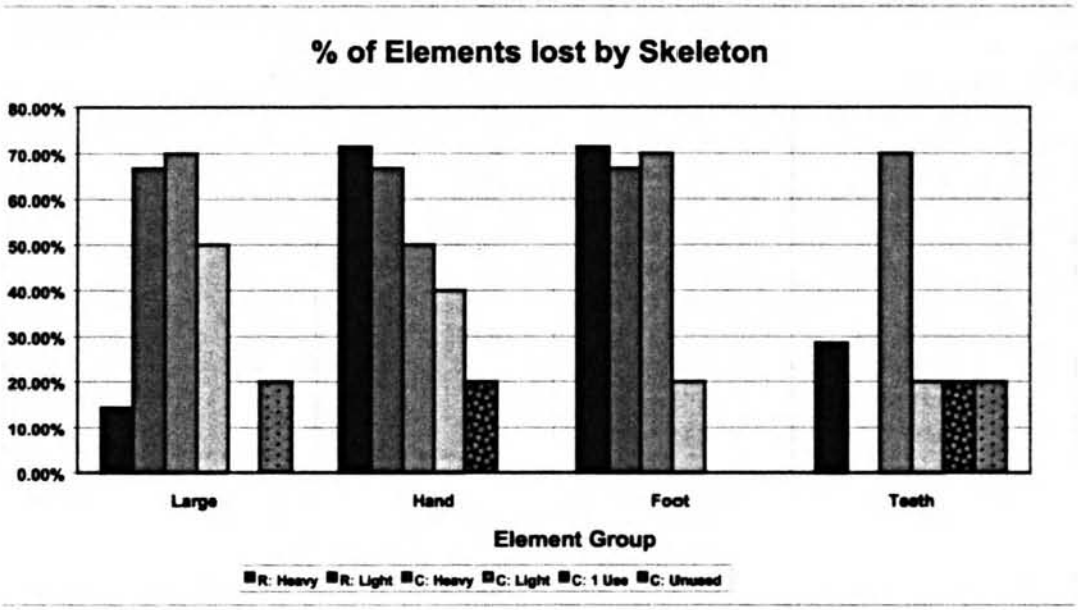

Fig. 4 – Percentage of skeletons with elements lost by element group therefore, were lost from the higher use groups, and this was also reflected in the sub-groups except for the hand elements (affected by the loss of hand elements from C348). The percentages of elements lost tended to be higher in the "light use" group, which can be explained by the initial number of elements present in each group. The "heavy use" group had an average of 90 elements per skeleton compared to the "light use" group that had an average of 58.1

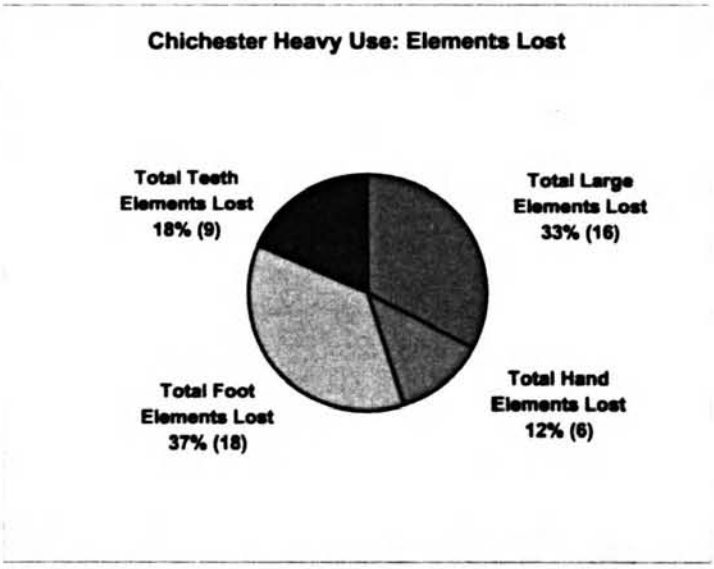

Fig. 5 – Chichester: heavy use group: total elements lost

On the whole, the proportions of teeth, hand and foot elements lost were greater than the proportions of large elements. However, the proportion of large elements lost in the Chichester "heavy use" group was greater than for the hand elements and teeth, and was almost equal to the proportion of foot elements lost (fig. 5).

The proportions of different tooth types lost are shown in Figure 6. This does not take into account the twenty-two teeth lost from C128, resulting from the loss of the entire mandible and maxilla, nor the four teeth lost from C40, because the teeth were initially glued into the wrong sockets. Canines proved to be the most frequently lost teeth, followed by the premolars. As expected, more single rooted teeth were lost since they are easily dislodged from the alveolar bone. Loose teeth were present for twenty-nine skeletons (72.5% of the sample), and represented 191 (31.2%) of the initial number of teeth.

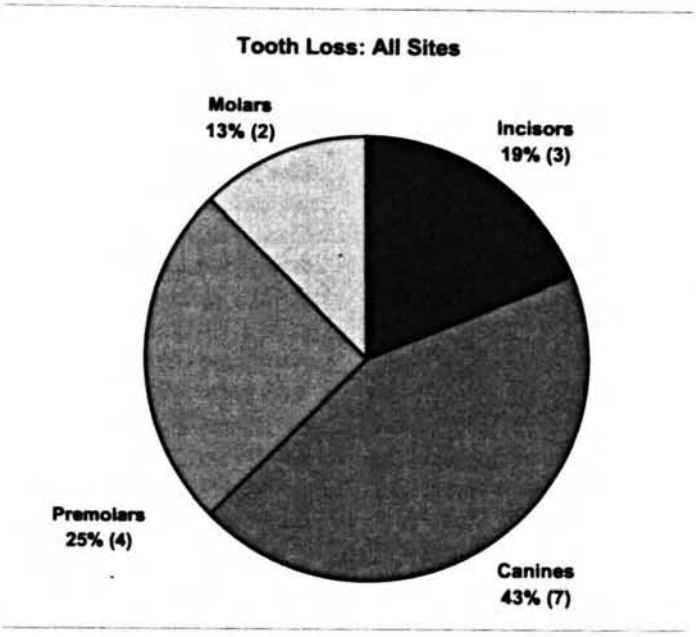

Fig. 6 – Tooth loss for both sites by tooth type

Fresh breaks and surface damage

The number of fresh breaks and surface damage was far greater in the "Old Chichester" skeletal material. Material from Raunds showed less post excavation damage, possibly due to differences in bone preservation between the two sites. The Chichester material, although more complete, is more friable, whereas the Raunds material is more robust despite being more fragmentary. There may also be a recording bias as fresh surface damage is more easily visible on the Chichester material, since it is darker in color. Photography of some of the elements, proved to be the best comparative tool. 35mm color slides were available for six of the selected skeletons, all from the "Old Chichester" group. Direct comparison of the elements with the slides showed conclusive evidence of recent breaks, particularly in the cranium of C187 (fig. 7). The slides taken of this individual also revealed that reconstruction work had been strengthened some time after the slide was taken.

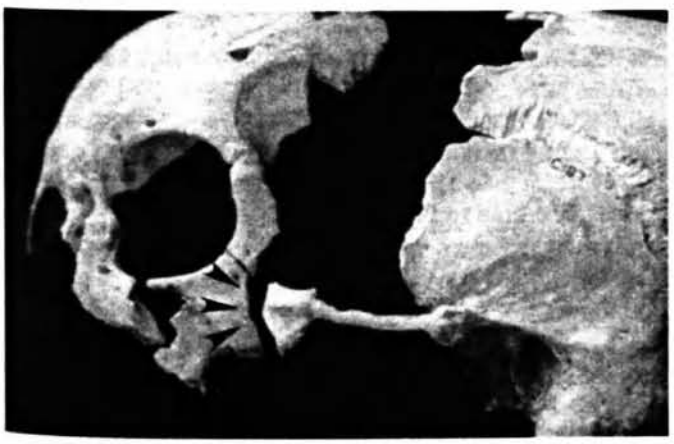

Fig. 7 – Breakage of skull following reconstruction (C187)

Repaired breaks and failed repairs

Repaired breaks and failed repair breaks were more common in the "Old Chichester" heavy use material. The incidences of repairs and failed repairs in the Raunds material were almost always restricted to the cranium. The percentage of failed repairs was low in the "New Chichester" material (around 6%) but was higher in the older material (around 30%). Analysis suggested that reconstruction of some bones may have caused some of the fresh breaks. Problems encountered with the various types of adhesive used on the collections included: gluing of teeth into incorrect sockets, and failure to clean break surfaces prior to repair, resulting in poor alignment of adhered fragments contributing to failure of the join. Blu-tack™ was apparently used to hold teeth in place, which is problematic, since this substance is radio-opaque. Traces of Blu-tack™ were also identified on other elements. Masking tape was used to reconstruct elements, or for the purposes of numbering ribs and vertebrae, and was often left in place (fig. 8). This may relate to student use for specific purposes; for example, there was a correlation between the use of tape on skeletons used for skeletal reporting by MSc in Osteology, Palaeopathology and Funerary Archaeology students.

Gained elements

Surprisingly, the total percentage of skeletons gaining elements was 62.5% on average. More skeletons gained hand and foot elements than large elements (Tables 4 and 5). More Raunds skeletons gained elements than did Chichester skeletons, and the correlation between elements lost and gained was high.

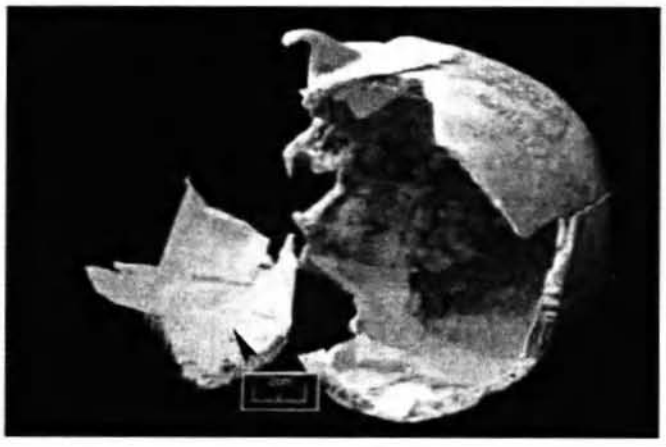

Fig. 8 – Excessive use of masking tape

Packaging

All the "Old Chichester" skeletons and most of the Raunds material were packed individually, i.e. one box per skeleton. Some of the Raunds skeletons share a box with one or more other skeletons. All the "New Chichester" material was packed in two boxes per skeleton (not a separate skull box, but two boxes of the same size), except C337, which was in three. In ten cases the length of the longest element (usually the femur) exceeded the length of the box; in all cases the femur had been wedged into the box diagonally. This is not recommended practice. Stroud (1989:48) recommends boxes, 'large enough to take a complete post cranial skeleton comfortably'.

Fragile elements such as the cranium and maxilla should have been packed in Layer 1 (the uppermost layer) with the heavier and more robust elements such as the lower limb bones in Layer 3. This was not, however, the case. Three (15%) of the "Old Chichester" had their crania packed in Layer 3 (the lowest layer), one (5%) had its mandible in Layer 3, and three (15%) had their mandibles in Layer 2. The maxilla, in one case, was packed in Layer 3. Furthermore, in one instance a large heavy non-human bone was found in a bag with the cranium and facial bones. There were also several instances where ribs, and pectoral and pelvic girdles were packed in Layer 3, and there were three cases (15%) where the lower limb bones were packed in Layer 1. The Raunds skeletons were in bags with all the elements from one side together, while the "New Chichester" skeletons were in more than one box. There was a tendency for the ribs of some of the Raunds skeletons to be packed at the bottom of the box in Layer 3 (6 skeletons or 60%).

Elements from the "New Chichester" skeletons were mostly unbagged. However, if they were bagged, usually the feet, hands, vertebrae and ribs benefited. All the skeletons from the "Old Chichester" group and from Raunds had initially been bagged, but in several cases elements were loose in the box. All the bagged "New Chichester" material was in sealable plastic bags, as were most of the "Old Chichester" skeletons. All the Raunds material was bagged in non-sealing plastic bags, which were sometimes stapled or closed with a paperclip. Material from Raunds tended to be packed in such a way that bones from one side of the body were in one bag, which led to large elements being in contact with smaller bones. All the Raunds and "Old Chichester" skeletal elements were marked with Indian ink. The "New Chichester" skeletons were unmarked.

Curation of Skeletal Collections at Other Institutions

A small survey of a number of institutions using human skeletal collections for teaching was carried out to provide a comparison to the curation and handling of skeletal remains at Bradford. The following questions were asked:

- How large are your teaching collections?
- How many students are taught physical anthropology?
- How many years have the collections been used for teaching?
- How many hours per week are they used?
- Are they available for visitors?
- Are casts or anatomical specimens used in preference to archaeological material?
- Is technical support available for curatorial purposes?
- What are the storage conditions and packaging used?
- Who prepares and puts away specimens used for laboratory classes?
- Is protective padding used to prevent damage?
- Do students wear protective clothing?
- Is a handling protocol in operation?
- Is handling monitored by anybody?

Although the intention is to undertake a more comprehensive study, the results showed a number of similarities to the data reported from Bradford. The size of skeletal collections varied from less than 100 to over 18,000 individuals. The numbers of students taking physical anthropology classes ranged from 5-10 to 40-50, with the average being taught over any one year being 15-25. The number of years that courses have been run ranged from three to over sixty years. Laboratory classes were run from two to 32 hours per week for two to 40 weeks per year. The most intensive teaching was for 32 hours per week for 40 weeks, although this was very much the exception. The lowest use was for two hours per week for ten weeks of the year. All the collections were available to visitors. Casts of specimens were preferred at four places, primarily for demonstration purposes or for rare examples. At only one institution was there any form of access policy. Only two institutions had technical support (at one, a part-time student). The largest collection was the only one, which had a full-time permanent technician.

Bubble wrap or tissue paper was used in three institutions for packaging; and in another bones were packed in plastic or paper bags. At another institution absorbent cotton, plus naphthalene balls as an insect repellent, were used. Two places did not provide any special packing for fragile or pathological specimens. Another two kept fragile or important specimens separate from the main collection. At

four institutions a designated person laid out and put away material for laboratories, and in one case the students were responsible. In all cases material was laid out on the day and in most it was packed away the same day. Access to the laboratory was denied in most cases during the period between the material being laid out and the class itself. Most institutions used protective padding on benches, although one did not and one used protection for fragile specimens only. In all cases no protective clothing was used (e.g. laboratory coat, gloves, dust masks), although gloves were available at one institution if needed. Instructions in handling and repacking were usually given, although the formality varied. Only one institution had a formal access agreement for visitors, and visitors were only monitored at one. Overall, there appears to be little standardization of care for human remains at teaching institutions.

Unfortunately, time constraints meant that only a small sample of the total collections at Bradford could be studied and only a limited number of institutions surveyed. However, on the basis of this study a number of recommendations for the future treatment of skeletal material curated by institutions and used for teaching and research can be made, although another paper by Janaway *et al.* (this volume) deals with these in more detail.

Discussion and recommendations

Teaching physical anthropology to large numbers of students not only puts pressure on staff and on available laboratory space, but also on the skeletal collections used. The obvious result of increased student numbers is that more students handle the material and thus increase the risk of damage. There is also a greater likelihood of material becoming lost and mixed. Furthermore, increased student numbers often mean that the same laboratory class may be run several times, which increases the exposure of the skeletons used. The less obvious result of increased student numbers is the pressure on teaching staff and technicians. Staff has less time to prepare laboratory classes and to repack material before the next class. The temptation is to leave material out for subsequent classes, thus increasing the risk of loss or damage when people use the laboratory in the intervening periods. In addition, with limited time available, material may not be repackaged properly or returned to its correct box. Curation is a full-time job, especially when 1500 skeletons are used up to 8-10 hours of per week during the academic year. Time, money and dedicated staff are required to ensure best practice.

Overall, the results suggest that the more skeletons are handled the greater the chance is that they will suffer loss of elements. A higher percentage of skeletons from the "heavy use" group suffered loss compared to the light and unused groups. In general, the number of elements lost from the "heavy use" group was greater. However, the loss of material from the light use groups resulted in a greater proportional loss of material compared to the initially better preserved "heavy use" skeletons. Smaller elements were lost most frequently.

The problems encountered when assessing use damage of skeletal material highlights the necessity of thorough documentation. It was originally assumed that element loss would be relatively easy to assess. However, due to the inadequate nature of the original documentation, in some cases even assessing loss proved difficult. The high number of gained elements, particularly for the hands and feet, also suggests inadequate initial recording. In addition, the level of documentation required to assess the incidence of fresh damage to the material was lacking. Although the condition of each element was compared to the original descriptions, they did not have the degree of accuracy or standardization required to assess whether the damage was recent or not. Only in cases where there were large fresh breaks was comparison with the original forms conclusive. For example, the pathological left tibia of C28 was recorded as being "complete" on the original form, but the proximal end is now shattered into three fragments with several more missing. Attempting to establish more minor instances of surface abrasion proved impossible. Bone loss and damage occurred more frequently in the "heavy use" group of skeletons, supporting the hypothesis that handling causes damage. Elements may be lost as a result of their removal from boxes and of failure to return them to the correct box. If elements are not labeled then this results in permanent loss of material.

The presence of loose elements in the bottom of skeleton boxes from Raunds and "Old Chichester" suggest that elements removed for study were not re-bagged before returning the material to its box. All bones and fragments of bones should be marked with the site code and skeleton number to reduce the risk of loss or mixing of skeletons. However, any labeled elements returned to incorrect boxes are effectively lost, as recovering them would require looking through all the boxes containing skeletons in the collections. Any fresh breaks will also produce unlabelled fragments or elements, thus increasing the chances of permanent loss of material. Elements may also be lost during unpacking and repacking of skeletons, as small elements may be caught up in packaging or, if dropped on the floor, can be easily overlooked. Loose teeth are also potentially easier to lose, as they are not held in, and protected by, the mandible and maxilla, and those that are replaced in their sockets have a tendency to fall out again during handling.

It is not so easy to overlook a large element, so loss in this case must imply either that the material was returned to the wrong box or that the elements were not returned at all. Six skeletons in the sample had labeled elements from another skeleton and labeled non-human bone was also found. Furthermore, it could be assumed that an increase in the number of fragments represents recent breaks, and a reduction represents loss of material. However, there are a number of problems with counting and comparing the number of fragments. Failure to record elements and fragments, or breakage of skeletal elements, could occur

simultaneously, with loss and gain of fragments from recent breaks canceling each other out. Differences in the identification of fragments, and in opinions of the minimum size for a fragment to be included in a count, will result in differences in numbers.

Element gain may be the result of inadequate original recording where elements (most commonly hand and foot bones) or fragments are incorrectly identified. On correct identification the number of fragments would increase from the original. During this study, whole elements were found in the "fragments" bag in a box. These were most commonly tarsals, carpals and phalanges. Identifiable fragments of other bones were also found, indicating inadequate initial documentation and/or mixing of elements during use by students. Mixing of material from other skeletons with the skeleton under study increases the number of elements present, but the gained elements were usually labeled with the correct skeleton number. Hand and foot elements are small and therefore are possibly more easily overlooked/ misidentified/ miscounted during initial recording (depending on the experience of the observer), elements may be lost from a foot and gained by a hand. Frequent misidentification and incorrect side assignation of hand and foot elements were noted for the Raunds material. There was also no differentiation of proximal, intermediate and distal phalanges and frequently no identification of right and left hand and foot bones. To complicate the matter there was no diagram, or table, of bones present and this information had to be deduced from the written comments. The documentation used may reflect the time period (knowledge and research objectives) when the skeletal material was recorded but this also has implications for the data actually recorded. The reader is referred to suggestions for initial recording of skeletal material, which are discussed by Janaway *et al.* (this volume).

Recent breaks tended to occur more in skeletons in the "heavy use" groups especially the "Old Chichester" skeletons. Post excavation surface damage was quite pronounced in the "Old Chichester" "heavy use" skeletons. The use of adhesive was more common in the Chichester material, and in the Raunds material was restricted to cranial reconstruction. The fresh breaks recorded might not have occurred during handling; some may be due to excavation, post-excavation processing or initial recording. This may explain the presence of fresh breaks in the "New Chichester" group of unused material. However, if all fresh breaks were caused in this way a more equal distribution across use groups would be expected. The number of breaks present in the unused material may be regarded as a baseline against which additional damage would indicate damage caused by handling. In any future study, photographic evidence should play a larger and more important part when comparing pre- and post-use damage because this provided indisputable evidence for recent breaks in elements from six of the selected skeletons. However, the cost implications would be considerable. The limitations of using photographic evidence, in this study, are that people tend to photograph only the interesting elements (e.g. pathological), and that even when an element is photographed, the relevant part may not be visible for a variety of reasons including focus and lighting. For human skeletal analysts to be familiar with changes due to postmortem damage and use, ongoing work must define the criteria for recognition of damage, particularly at the macroscopic level. The physical anthropologist also needs to consider whether (and how many) elements of the skeleton are going to be radiographed and photographed, or even cast; these forms of data are essential for the original record of the skeleton and will help with assessment of future use damage. Ultimately, if these problems and recommendations are not attended to, the condition, and therefore value for teaching and research, of skeletal collections will inevitably decline. As a consequence, the justification for retention of skeletal material for curation and study will be difficult to support.

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Anwen Caffell received a BSc (Hons) in Archaeology at the University of Bradford, in 1997. Her placement year was spent with the York Archaeological Trust Conservation Laboratories (6 months) and the Museum of London Archaeology Service (6 months). In addition she has excavated on various archaeological sites and has experience in excavating inhumations. She completed her MSc in Osteology, Palaeopathology and Funerary Archaeology at the Universities of Bradford and Sheffield (1999), funded by the NERC, and is currently a PhD student at the University of Durham.

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Robert Janaway began excavating in 1970, throughout the decade he continued to excavate on a range of sites including a number of sites with inhumation burials. He completed his BSc Archaeological Conservation at University College Cardiff. While employed as a conservator at the University of Leeds, he instigated the conference that led to the edited volume *Death, Decay and Reconstruction (1986)*. In 1986 he moved to the Department of Archaeological Sciences, Bradford University, where he currently holds a lecturing post. His current research interests include the taphonomy of inhumation graves.

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